WHAT IS CLAIMED IS:

1. A quantum dot, comprising:

a nanocrystalline core exhibiting quantum confinement and having a band gap;

a luminescence promoter linked to the surface of the nanocrystalline core; and

the luminescence promoter selected from the group consisting of an ethylene glycol unit, an alkylthio acid, mercaptoacetic acid, and any combination of these.

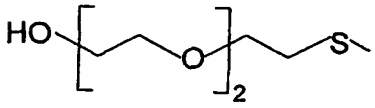
2. The quantum dot of claim 1, comprising

a non-zinc linking group; and

an ethylene glycol unit linked to the surface of the nanocrystalline core through the linking group.

3. An ethylene-glycol-functionalized quantum dot of claim 2, wherein the linking group does not comprise a group VA or VIA element which is present in the nanocrystalline core.

4. The ethylene-glycol-functionalized quantum dot of claim 2, comprising a group of formula XI, comprising a sulfur atom, wherein the sulfur atom is linked to the surface of the nanocrystalline core.



XI

5. The ethylene-glycol-functionalized quantum dot of claim 4, wherein the nanocrystalline core comprises cadmium telluride.

6. The quantum dot of claim 1, further comprising a biofunctional group linked to the surface of the nanocrystalline core.

7. The biofunctionalized quantum dot of claim 6, wherein the biofunctionalized quantum dot is stable in aqueous solution under storage in the dark at 4 °C for at least 4 months with respect to luminescence, precipitation, flocculation, and leaching of the biofunctional group.

8. A formulation comprising:

a liquid; and

the biofunctionalized quantum dot of claim 6,

wherein the biofunctionalized quantum dot is dissolved or suspended in the liquid and wherein the biofunctionalized quantum dot does not precipitate or flocculate.

9. A method of medical imaging, comprising:

providing a biofunctionalized quantum dot of claim 6,

contacting the biofunctionalized quantum dot with a biological material;

exposing the biological material to light having a wavelength effective to cause the biofunctionalized quantum dot to luminesce; and

imaging the luminescing quantum dots,

wherein the biofunctionalized quantum dot is functionalized with an antigen or a set of antigens and

wherein the biofunctional group comprises a saccharide and/or the biofunctionalized quantum dot further comprises a mercaptoalkanoic acid linked to the surface of the nanocrystalline core.

10. A method of therapy, comprising the steps of:

providing a biofunctionalized quantum dot of claim 6; and

contacting the biofunctionalized quantum dot with a biological material and thereby treating a disease,

wherein the biofunctional group comprises a saccharide and/or the

biofunctionalized quantum dot further comprises a mercaptoalkanoic acid linked to the surface of the nanocrystalline core.

11. A quantum dot coated device,

comprising the biofunctionalized quantum dot of claim 6,

wherein the biofunctionalized quantum dot is linked to the surface of the device to form a coating on the device and

wherein the biofunctional group comprises a saccharide and/or the quantum dot further comprises a mercaptoalkanoic acid linked to the surface of the nanocrystalline core.

12. A cell-quantum dot complex, comprising:

the biofunctionalized quantum dot of claim 6; and

a cell,

wherein the biofunctional group is complexed with the cell and

wherein the biofunctional group comprises a saccharide and/or the quantum dot further comprises a mercaptoalkanoic acid linked to the surface of the nanocrystalline core.

13. The biofunctionalized quantum dot of claim 6,

wherein the luminescence promoter is mercaptoalkanoic acid,

wherein the mercaptoalkanoic acid is not linked to the surface of the nanocrystalline core through a zinc atom, and

wherein the biofunctional group is not linked to the surface of the nanocrystalline core through a zinc atom.

14. A biofunctionalized quantum dot of claim 6, wherein

the luminescence promoter is mercaptoalkanoic acid,

the mercaptoalkanoic acid is not linked to the surface of the nanocrystalline core through a group VA or VIA element which is present in the nanocrystalline core, and

the biofunctional group is not linked to the surface of the nanocrystalline

core through a group VA or VIA element which is present in the nanocrystalline core.

15. The biofunctionalized quantum dot of claim 6, wherein the luminescence promoter comprises a non-zinc linking group and an ethylene glycol unit linked to the surface of the nanocrystalline core through the linking group.

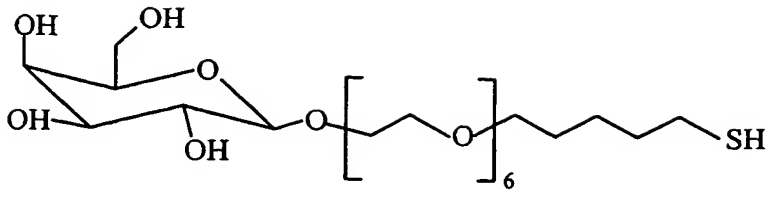
16. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, wherein the linking group does not comprise a group VA or VIA element which is present in the nanocrystalline core.

17. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, further comprising a substantially zinc-free shell layer overcoating the nanocrystalline core.

18. The ethylene-glycol- and bio-functionalized quantum dot of claim 17,
the shell layer comprising cadmium sulfide; and
the nanocrystalline core comprising cadmium telluride and/or cadmium selenide.

19. The ethylene-glycol- and bio-functionalized quantum dot of claim 17,
the shell layer comprising mercury sulfide; and
the nanocrystalline core comprising mercury telluride and/or mercury selenide.

20. The ethylene-glycol- and bio-functionalized quantum dot of claim 19, comprising a group of formula XXX, comprising a sulfur atom, wherein the sulfur atom is linked to the surface of the nanocrystalline core.



XXX

21. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, wherein the biofunctional group comprises at least one biofunctional unit which is not a peptide.

22. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, the biofunctional group comprising a biofunctional unit selected from the group consisting of a monosaccharide unit, a mononucleoside unit, a mononucleotide unit, a monopeptide unit, a glycopeptide unit, and any combination of these.

23. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, the biofunctional group comprising a biofunctional unit comprising a lipid unit and/or a glycolipid unit.

24. The ethylene-glycol- and bio-functionalized quantum dot of claim 22, the biofunctional group comprising at least one monosaccharide unit.

25. The ethylene-glycol- and bio-functionalized quantum dot of claim 22, the biofunctional group not comprising mannose or dextran.

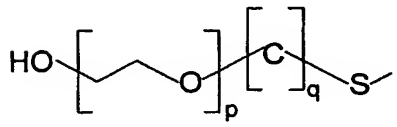
26. The ethylene-glycol- and bio-functionalized quantum dot of claim 24, the biofunctional group comprising at least one tumor-associated carbohydrate.

27. The ethylene-glycol- and bio-functionalized quantum dot of claim 24, wherein the biofunctional group comprises a Thomsen-Friedenreich disaccharide.

28. The ethylene-glycol and bio-functionalized quantum dot of claim 27, that selectively complexes to endothelial cells.

29. The ethylene-glycol and bio-functionalized quantum dot of claim 27, that is substantially retained by agarose-bound galactose specific peanut agglutinin and that is not substantially retained by agarose-bound mannose/glucose-specific *Pisum savitum* agglutinin.

30. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, comprising an ethylene glycol thiol of formula XIII comprising a sulfur atom,



XIII

wherein the sulfur atom is linked to the surface of the nanocrystalline core, p is a positive integer, and q is an integer of at least two.

31. The ethylene-glycol- and bio-functionalized quantum dot of claim 30, wherein p is two and q is two.

32. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, comprising a branched linked chain comprising the ethylene glycol unit.

33. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, comprising a carboxylic acid unit linked to the surface of the nanocrystalline core.

34. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, comprising:

at least one ethylene-glycol-containing linked chain; and

at least one biofunctional-group-containing linked chain,

wherein the ratio of ethylene-glycol-containing linked chains to biofunctional-group-containing linked chains is in the range of from about 1:1 to about 5:1.

35. The ethylene-glycol- and bio-functionalized quantum dot of claim 34, wherein the ratio of ethylene-glycol-containing linked chains to biofunctional-group-containing linked chains is about 1:3.

36. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, comprising:

an ethylene-glycol-containing linked chain; and

a biofunctional-group-containing linked chain,

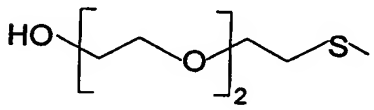
wherein the ethylene-glycol-containing linked chain does not comprise a biofunctional group and

wherein the biofunctional-group-containing linked chain does not comprise an ethylene glycol unit.

37. The ethylene-glycol- and bio-functionalized quantum dot of claim 36, wherein the ethylene-glycol-containing linked chain comprises from 3 to 6 ethylene glycol units.

38. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, comprising:

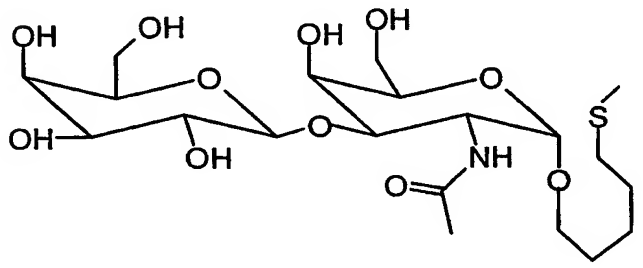
an ethylene-glycol-containing linked chain of formula XI, the sulfur atom of the ethylene-glycol-containing linked chain of formula XI linked to the surface of the nanocrystalline core; and



XI

a biofunctional-group-containing linked chain of formula XXVIIa, comprising a Thomsen-Friedenreich disaccharide as the biofunctional group and five carbon atoms and a sulfur atom,

wherein the sulfur atom of the biofunctional-group-containing linked chain of formula XXVIIa is linked to the surface of the nanocrystalline core.



XXVIIa

39. The ethylene-glycol- and bio-functionalized quantum dot of claim 38, the nanocrystalline core consisting of cadmium telluride.

40. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, comprising:

a biofunctional-group-containing linked chain, wherein

the ethylene glycol unit is part of the biofunctional-group-containing linked chain and

the biofunctional group is part of the biofunctional-group-containing linked chain.

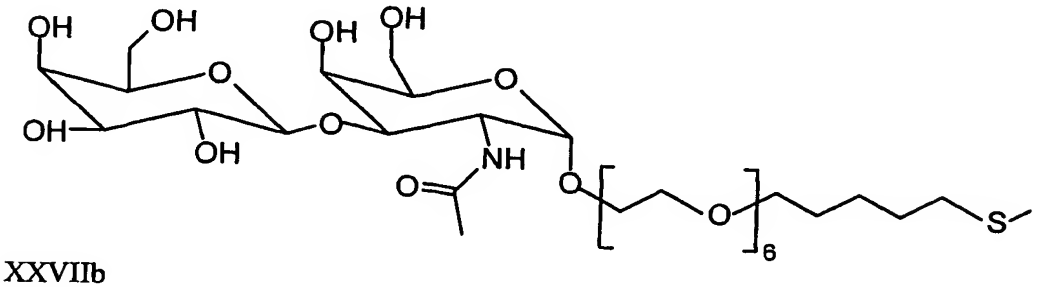
41. The ethylene-glycol- and bio-functionalized quantum dot of claim 15, further comprising

a biofunctional-group-containing linked chain of formula XXVIIb, comprising a Thomsen-Friedenreich disaccharide as the biofunctional group and

comprising six ethylene glycol units, five carbon atoms, and a sulfur

atom,

wherein the sulfur atom of the biofunctional-group-containing linked chain of formula XXVIIb is linked to the surface of the nanocrystalline core.



XXVIIb

42. A formulation comprising:

a liquid; and

the ethylene-glycol- and bio-functionalized quantum dot of claim 15,

wherein the ethylene-glycol- and bio-functionalized quantum dot is dissolved or suspended in the liquid.

43. The formulation of claim 42, wherein the ethylene-glycol- and bio-functionalized quantum dot essentially does not precipitate or flocculate.

44. The ethylene-glycol and bio-functionalized quantum dot of claim 15, that is stable in aqueous solution under storage at room temperature in ambient lighting for at least 4 months with respect to luminescence, precipitation, and flocculation.

45. A method of imaging, comprising:

providing the ethylene-glycol- and bio-functionalized quantum dot of claim 15;

contacting the ethylene-glycol- and bio-functionalized quantum dot with a biological material;

exposing the biological material to light having a wavelength effective to

cause the quantum dot to luminesce; and

imaging the luminescing quantum dots.

46. The method of claim 45, further comprising imaging the luminescing quantum dot adhered to a secretion of the biological material.

47. The method of claim 45, further comprising imaging the luminescing quantum dot in vivo.

48. The method of claim 45, further comprising dissolving or suspending the ethylene-glycol- and bio-functionalized quantum dot in a biocompatible solvent.

49. The method of claim 45, the biological material comprising a cell culture and/or a tissue.

50. The method of claim 45, the contacting comprising injecting the ethylene-glycol- and bio-functionalized quantum dot into a tissue of a living animal.

51. The method of claim 45, wherein the biofunctional group exhibits high affinity to tissue in a diseased or abnormal state, and the quantum dot luminescence images the tissue.

52. The method of claim 51, the diseased or abnormal state being cancerous.

53. A method of medical imaging, comprising:

providing a first biofunctionalized quantum dot of claim 15 having a first characteristic wavelength,

providing a second biofunctionalized quantum dot of claim 15 having a second characteristic wavelength,

contacting the first biofunctionalized quantum dot and the second biofunctionalized quantum dot with a biological material;

exposing the biological material to light having a wavelength effective to

cause the first biofunctionalized quantum dot and the second biofunctionalized quantum dot to luminesce; and

imaging the luminescing quantum dots,

wherein the first biofunctionalized quantum dot is functionalized with a first antigen or a first set of antigens,

wherein the second biofunctionalized quantum dot is functionalized with a second antigen or a second set of antigens,

wherein the biofunctional group of at least one of the first biofunctionalized quantum dot and the second biofunctionalized quantum dot comprises a saccharide and/or at least one of the first biofunctionalized quantum dot and the second biofunctionalized quantum dot further comprises a mercaptoalkanoic acid linked to the surface of the nanocrystalline core.

54. A method of therapy, comprising:

providing an ethylene-glycol- and bio-functionalized quantum dot of claim 15; and

contacting the ethylene-glycol- and bio-functionalized quantum dot with a biological material and thereby treating a disease.

55. The method of claim 54, the biofunctional group comprising an immune-response stimulating group.

56. The method of claim 54, the biofunctional group comprising a tumor-associated antigen.

57. The method of claim 54, the contacting comprising injecting the ethylene-glycol- and bio-functionalized quantum dot into a tissue of a living animal.

58. The method of claim 54, wherein the disease is cancer.

59. The method of claim 54, wherein the quantum dot further comprises a therapeutic agent linked to the surface of the nanocrystalline core.

60. The method of claim 54, wherein a shell layer and/or the nanocrystalline core comprises a therapeutic agent.

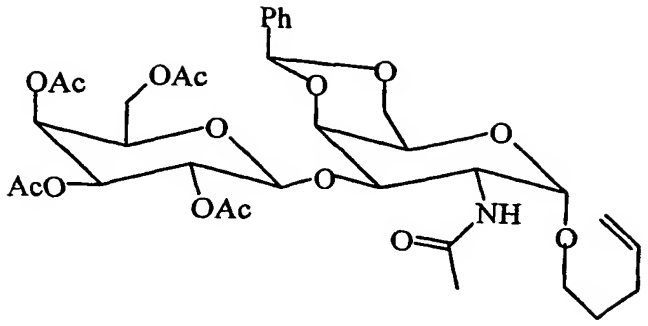
61. A quantum dot coated device, comprising the ethylene-glycol- and bio-functionalized quantum dot of claim 15 linked to the surface of the device to form a coating on the device.

62. A cell-quantum dot complex, comprising:
a cell; and
the ethylene-glycol- and bio-functionalized quantum dot of claim 15, wherein the biofunctional group is complexed with the cell.

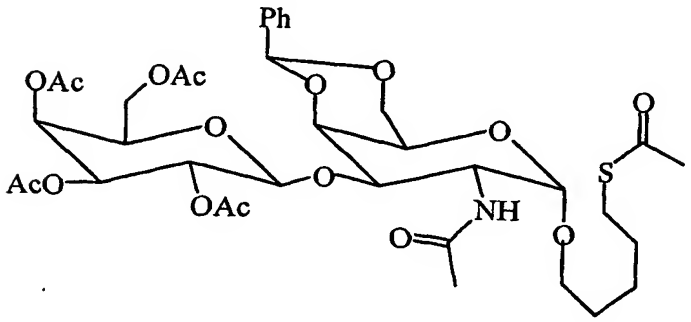
63. A method for producing a quantum dot, comprising:
providing a luminescence promoter;
refluxing the luminescence promoter with a group IIB element salt, a hydrogen-alkali-group VIA element compound, and a suitable solvent to produce a quantum dot in a solution,
wherein the luminescence promoter is selected from the group consisting of an ethylene glycol unit, an ethylene glycol thiol, an alkylthio acid, mercaptoacetic acid, and any combination of these.

64. The method of claim 63, comprising:
providing a biofunctional group-thiol, comprising a biofunctional unit; and
refluxing the biofunctional group-thiol and the luminescence promoter with a group IIB element salt, a hydrogen-alkali-group VIA element compound, and a suitable solvent to produce a quantum dot in a solution.

65. The method of claim 64, comprising:
reacting a glycoside of formula IV with an alkylthio acid in the presence of 2,2'-azobisisobutyronitrile in 1,4-dioxane at about 75 °C to produce a thioester of formula V;



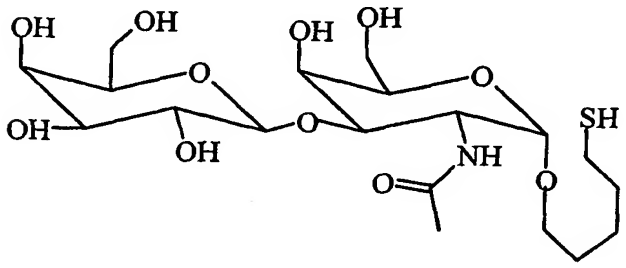
IV



V

debenzylidinating the thioester of formula V;

hydrolyzing the debenzylidinated thioester of formula V to produce a Thomsen-Friedenreich-thiol of formula VI; and



VI

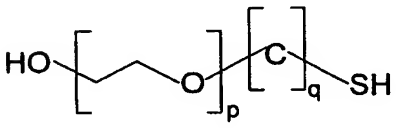
refluxing the Thomsen-Friedenreich-thiol of formula VI with cadmium perchlorate, a luminescence promoter, hydrogen sodium telluride, and a suitable

solvent, to produce a Thomsen-Friedenreich-functionalized quantum dot in a solution,

wherein the suitable solvent comprises water and/or N,N-dimethylformamide.

66. A method for producing a quantum dot, wherein the luminescence promoter comprises an ethylene glycol thiol.

67. The method of claim 66, wherein
the ethylene glycol thiol is of formula XIII,



XIII

wherein p is a positive integer and q is an integer of at least two.

68. The method of claim 67, wherein the refluxing further comprises refluxing with mercaptoacetic acid.

69. The method of claim 67, wherein p is two and q is two.

70. The method of claim 67,
wherein the group IIB element salt is cadmium perchlorate and
wherein the hydrogen-alkali-group VIA element compound is hydrogen sodium telluride.

71. A method for producing a quantum dot, comprising:
providing a biofunctional group-thiol, comprising a biofunctional unit;
providing an ethylene glycol unit; and
refluxing the biofunctional group-thiol and the ethylene glycol unit with a

group IIB element salt, a hydrogen-alkali-group VIA element compound, and a suitable solvent to produce a quantum dot in a solution.

72. The method of claim 71, wherein the suitable solvent comprises water and/or N,N-dimethylformamide.

73. The method of claim 71, further comprising:
purifying the solution; and
drying the purified solution.

74. The method of claim 73, the purifying comprising separating the bio-functionalized quantum dot from the remainder of the solution by filtration through an ultrafiltration filter.

75. The method of claim 73, further comprising dissolving or suspending the purified and dried ethylene-glycol- and bio-functionalized quantum dot preparation in an aqueous solvent.

76. The method of claim 71, conducting the refluxing for from about 6 to about 170 hours.

77. The method of claim 76, conducting the refluxing for about 40 hours.

78. The method of claim 71, further comprising:
reacting a glycoside of formula XVIII with an alkylthio acid in the presence of a catalyst to produce an acetylated, benzylidenated biofunctional group thiol of formula XIX;

XVIII

XIX

debenzylidenating the thioester of formula XIX; and

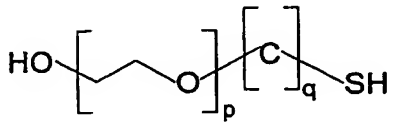
hydrolyzing the thioester of formula XIX to produce the biofunctional group-thiol of formula XVb,

XVb

wherein R_{12} comprises a carbon atom and R_{13} comprises a carbon atom.

79. The method of claim 78,

wherein the refluxing further comprises refluxing with an ethylene glycol thiol of formula XIII,



XIII

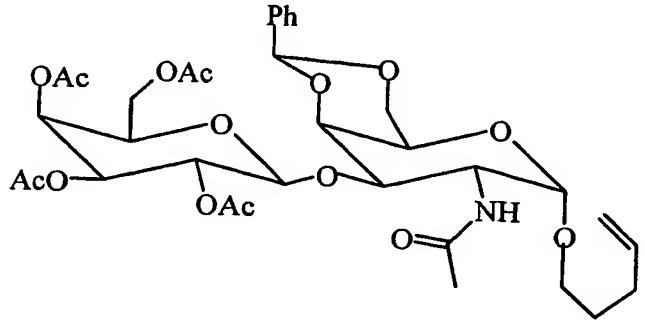
wherein p is a positive integer, q is an integer of at least two, and the ethylene glycol thiol of formula XIII and the biofunctional group thiol are in a ratio of from about 1:1 to about 5:1.

80. The method of claim 79, wherein the ethylene glycol thiol of formula XIII and the biofunctional group thiol are in a ratio of about 3:1.

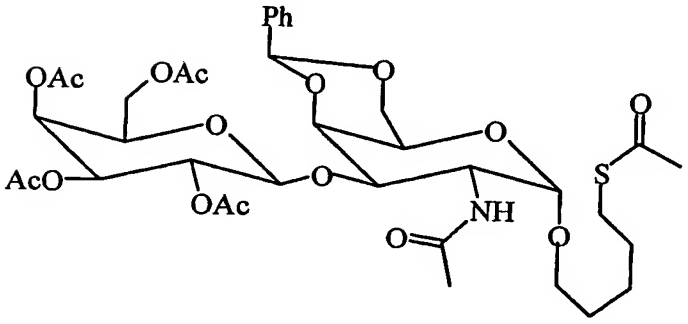
81. The method of claim 78, further comprising:

reacting a glycoside comprising a Thomsen-Friedenreich disaccharide of

formula XXV with mercaptoacetic acid in the presence of 2,2'-azobisisobutyronitrile in 1,4-dioxane at about 75 °C and quenching with cyclohexane to produce a thioester of formula XXVI;



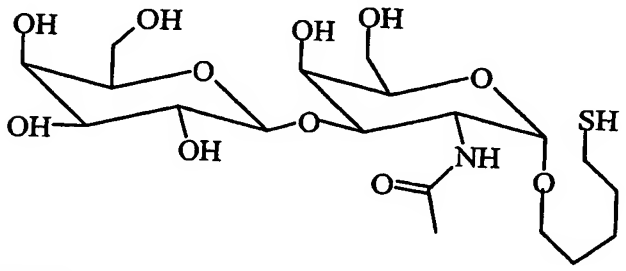
XXV



XXVI

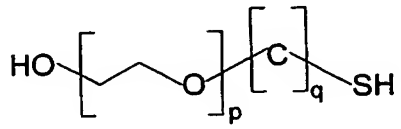
debenzylidinating the thioester of formula XXVI; and

hydrolyzing the debenzylidinated thioester of formula XXVI to produce a biofunctional-group thiol of formula XXVII,



XXVII

wherein the refluxing further comprises refluxing with an ethylene glycol thiol of formula XIII,



XIII

wherein the group IIB element salt is cadmium perchlorate,

wherein the hydrogen-alkali-group VIA element compound is hydrogen sodium telluride,

wherein p is two and q is two, and

wherein the suitable solvent comprises water and/or N,N-dimethylformamide.

82. The method of claim 81, the debenzylidinating comprising

treating the thioester of formula XXVI with aqueous acetic acid at about 45 °C and

evaporating to obtain debenzylidinated thioester.

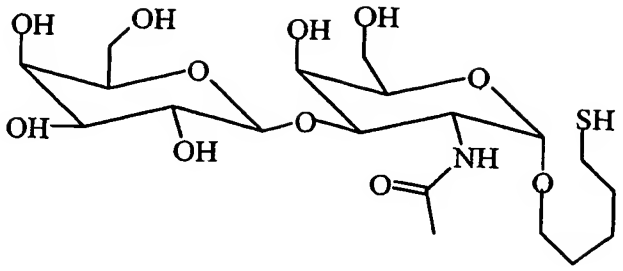
83. The method of claim 81, the debenzylidinating comprising

treating the thioester of formula XXVI with acetyl chloride in methanol,

adding pyridine to the thioester of formula XXVI with acetyl chloride in methanol for quenching the reaction, and

evaporating to obtain debenzylidinated thioester.

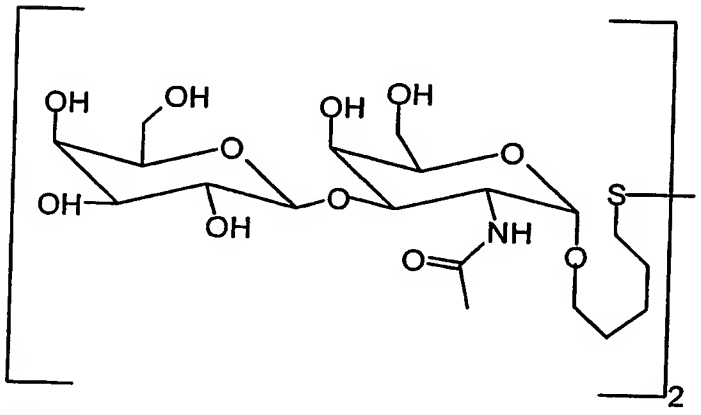
84. The method of claim 81, the hydrolyzing comprising treating the debenzylidinated thioester with sodium methoxide in methanol to produce the Thomsen-Friedenreich-thiol of formula XXVII.



XXVII

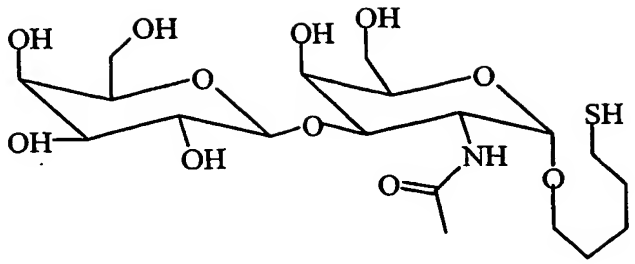
85. The method of claim 81, the hydrolyzing comprising

treating the debenzylidinated thioester with sodium methoxide in methanol while bubbling air through the debenzylidinated thioester, sodium methoxide, and methanol to produce a Thomsen-Friedenreich-disulfide of formula XXVIII and



XXVIII

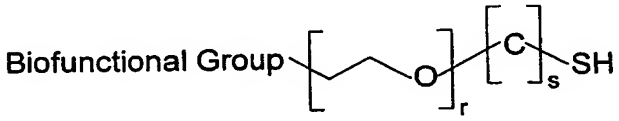
treating the Thomsen-Friedenreich-disulfide of formula XXVIII with dithiothreitol in water to produce the Thomsen-Friedenreich-thiol of formula XXVII.



XXVII

86. The method of claim 71,

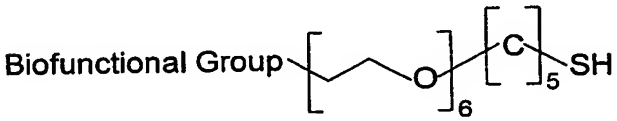
wherein the biofunctional group-thiol comprises a thiol of formula XVIb and



XVIb

wherein r is a positive integer and s is an integer of at least two.

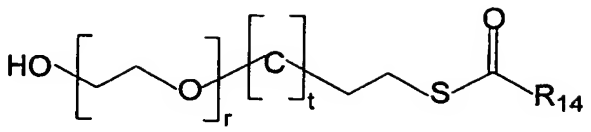
87. The method of claim 86, wherein the biofunctional group-thiol comprises a thiol of formula XVIIb.



XVIIb

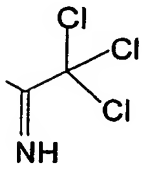
88. The method of claim 86, further comprising:

reacting a compound comprising ethylene glycol of formula XXb

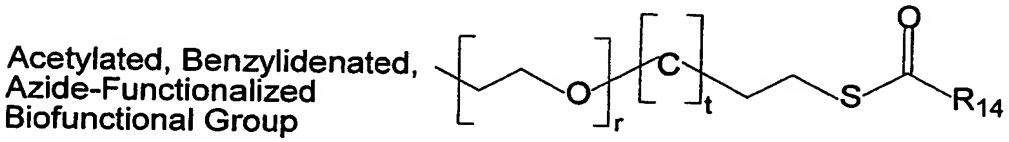


XXb

with a glycoside having azide and a group of formula XXbb as pendant groups and quenching the reaction with triethylamine to produce a compound of formula XXIIIb;

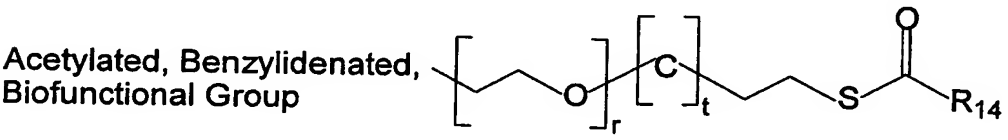


XXbb



XXIIIb

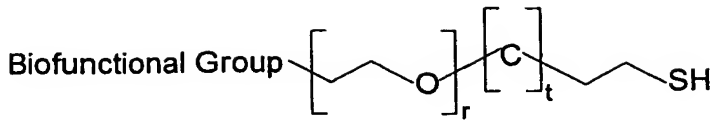
treating the compound of formula XXIIIb with acetic anhydride and a reducing agent to produce a compound of formula XXIIIc in which the azide group of formula XXIIIb is replaced with an acetamido group;



XXIIIc

debenzylidenating the compound of formula XXIIIc; and

hydrolyzing the compound of formula XXIIIc to produce the biofunctional-group thiol of formula XXIVb,



XXIVb

wherein r is a positive integer, t is zero or a positive integer, and R_{14} comprises a carbon atom.

89. The method of claim 88,

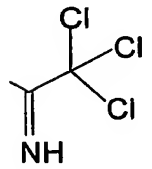
wherein the group IIB element salt is cadmium perchlorate,

wherein the hydrogen-alkali-group VIA element compound is hydrogen sodium telluride,

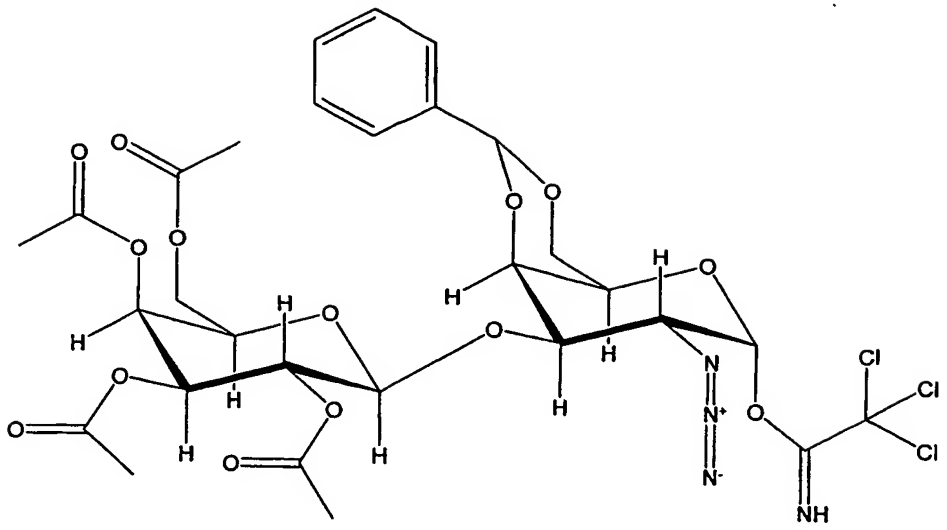
wherein r is six and t is three,

wherein R_{14} is methyl,

wherein the glycoside having an azide and a group of formula XXbb as pendant groups has formula XXII,



XXbb



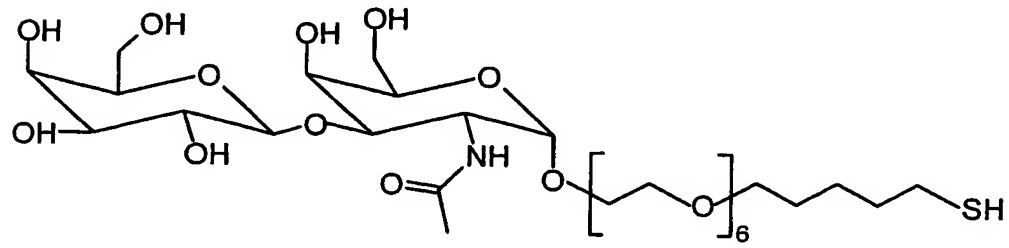
XXII

wherein the reducing agent is zinc,

wherein the debenzylidenating comprises treatment with acetyl chloride and quenching with pyridine;

wherein the hydrolyzing comprises treatment with sodium methoxide and quenching with ion-exchange resin, and

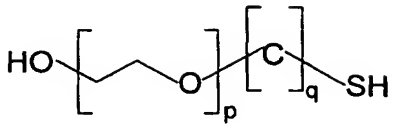
wherein the biofunctional-group thiol is of formula XXIVc.



XXIVc

90. The method of claim 88,

wherein the refluxing further comprises refluxing with a luminescence promoter comprising mercaptoacetic acid and/or an ethylene glycol thiol of formula XIII,



XIII

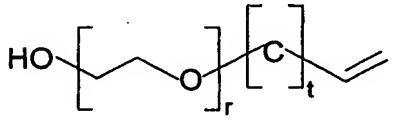
wherein p is a positive integer and q is an integer of at least two.

91. The method of claim 90, wherein the luminescence promoter and the biofunctional group thiol are in a ratio of from about 1:1 to about 5:1.

92. The method of claim 91, wherein the luminescence promoter and the biofunctional group thiol are in a ratio of about 3:1.

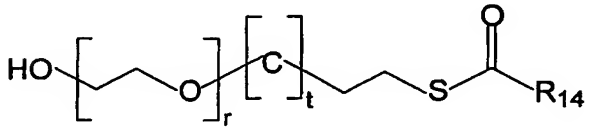
93. The method of claim 71, further comprising:

reacting a polyethylene glycol with sodium hydroxide and a brominated alkene to produce a compound of formula XXa; and



XXa

reacting the compound of formula XXa with an alkylthio acid in the presence of a catalyst to produce a compound of formula XXb,



XXb

wherein r is a positive integer, t is zero or a positive integer, and R_{14} comprises a carbon atom.

94. The method of claim 71, comprising refluxing the biofunctional group-thiol of formula III with a group IIB element salt, a hydrogen-alkali-group VIA element compound, and a suitable solvent to produce a quantum dot in a solution,

III

wherein R_1 comprises a carbon atom and/or an ethylene glycol unit, wherein the group IIB element comprises cadmium and/or mercury, and wherein the group VIA element comprises tellurium and/or selenium.